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PROFIT IN SPRAYING ORCHARDS AND VINEYARDS.

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PROFIT IN SPRAYING ORCHARDS AND VINEYARDS

BY W J GREEN

Ohio has more than half a million acres of orchards and vineyards, and all of the trees and vines covering these acres are subject to the attacks of insects and fungous diseases How much damage these insects and diseases do, or are capable of doing, cannot well be estimated, but it is possible to approximate quite closely to the benefit to be derived from the use of preventive and remedial measures against them. It was demonstrated at this Station in 1891 that a certain course of treatment enhanced the value of the apple crop not less than $20 00 per acre, and in 1892 the same treatment prevented a loss of a still greater amount

The value of treatment to prevent premature leaf dropping of plum and pear trees, in connection with the use of Paris green for the curculio, is even greater than in the case of apples. Treatment for the grape rot yields still higher returns Although all classes of insects and all fungous diseases cannot be successfully controlled, enough is known concerning methods of treatment to warrant the statement that were these methods put into practice generally, the returns from the fruit crop of the state would annually exceed its present value by several millions of dollars Full demonstration of the truth of this statement may be found in the reports and bulletins issued by the United States Department of Agriculture and by the various experiment stations.

The design of this bulletin is not so much to add more facts by way of further demonstration, as to put into available form such instructions as are needed by those who have not followed the work of this and other experiment stations. It is something of a departure from the method of giving the results of experiments, mainly, instead of instructions, but the numerous letters of inquiry, and questions asked at institutes, show that there is interest in the subject, and that many are in need of further light Even those who have given the matter considerable attention have become somewhat confused, owing to the variety of mixtures recommended by different experimenters, and to the unfamiliar names of chemicals

Combined Mixtures

It is not proposed, however, to cover the whole field of spraying operations, but to confine the limits of the bulletin almost entirely to the consideration of the treatment of some of the most destructive fungous diseases and most troublesome insects affecting fruit trees, in one operation, by the use of combined mixtures. For certain reasons this plan will be departed from to some extent, but the subject of combination fungicides and insecticides is of sufficient importance to merit special prominence.

Combined mixtures have a wider range of usefulness than is commonly supposed; in fact our leading fruit crops may be best treated in this manner. In most cases where either Paris green or London purple is to be used for insects it is much better to apply them in connection with Bordeaux mixture than alone, and in some cases where the treatment is specially for a fungous disease it is well to add an arsenite. The following reasons may be assigned for using arsenites (London purple and Paris green) in combination with Bordeaux mixture:

(1.) Where both are required, time is saved by using them in combination.

(2.) The Bordeaux mixture prevents the arsenite doing harm to the foliage.

(3.) Either is quite as efficient in combination as alone, and in some cases more so.

(4.) It is not always known whether one or both are needed, hence as a precaution it is better to use both in combination.

Mixtures Used in Spraying.

Dilute Bordeaux mixture:

Copper sulphate (blue vitrol) 4 pounds.
Quick lime, 4 pounds.
Water, 50 gallons.

Dissolve the copper sulphate in two gallons of hot water, and pour into the barrel or tank used in spraying, after which fill the tank nearly half full of cold water. Slake the lime in another vessel and pour into the copper sulphate solution, straining through a brass wire strainer with about thirty meshes to the inch. The lime will not dissolve readily, hence after pouring off each time more water is to be added to the lime and poured off as before, until nearly all the lime is dissolved, or taken up in suspension, which is really the case. Water to make 40 or 50 gallons in all is then to be added.

A stronger mixture is somtimes made by using three or four times the quantities of copper sulphate and lime above specified.

Cautions: Do not use air slaked lime, and do not slake the lime in large quantities and allow to stand before using. Do not mix the copper sulphate solution and lime water before cooling by the addition of water, as above directed.

Copper-arsenic solution.

Copper carbonate, 6 ounces.
Paris green, 4 ounces.
Ammonia, 2 quarts.
Lime water, 50 gallons.

The copper carbonate and Paris green may be mixed and dissolved in the ammonia (more or less ammonia will be required according to strength), after which add the lime water. By lime water is here meant clear lime water made by dissolving as much lime in water as it will take up. One-fourth pound of lime to a barrel of water is as much as is required for the purpose of preventing the injury to the foliage which the Paris green might cause. A convenient method is to put several pounds of lime in a barrel and then fill with water; after stirring vigorously allow to settle, when the clear water may be used The barrel may be filled with water each time before going to the orchard and allowed to stand while gone

Cautions: Use enough ammonia to dissolve the Paris green and copper carbonate, but no more, and no more lime than above specified:

Ammoniacal solution of copper carbonate.

Copper carbonate, 6 ounces.
Ammonia, 3 pints.
Water, 50 gallons.

Dissolve the copper carbonate in the ammonia and add the water.

Caution: Use no more ammonia than is required to dissolve the copper carbonate. Ammonia is variable in strength, and the amount required must be tested in practice.

To make copper carbonate at a cost of one-third the usual price: Dissolve 10 pounds copper sulphate (blue vitriol) in 10 gallons of hot water, also 12 pounds carbonate of soda in same quantity of water. After cooling, mix the two solutions and stir well. Allow the mixture to stand twenty-four hours and settle, after which pour off the liquid. Add the same quantity of water as before, stir and allow to stand same length of of time. Repeat the operation again, after which drain and dry the blue powder, which is copper carbonate.

Numerous other mixtures have been used and recommended by experimenters, but the above have been found to be satisfactory, and for various reasons are believed to be the best for general use. The Bordeaux mixture is the most useful of all, but in certain cases, which will

be specified, one of the others may take its place. The arsenites, London purple, Paris green, or white arsenic, may be employed to destroy such insects as are mentioned in this bulletin, but the first named is preferable in most cases, because of its cheapness, although Paris green has the advantage of being an insecticide and to some extent a fungicide, as it contains some copper. If used in combination with Bordeaux mixture they are not likely to injure the foliage, but if applied alone London purple is more harmful than Paris green, and must be used with care, and especial pains taken to keep the mixture well stirred, so as not to allow any of the poison to settle to the bottom of the barrel, as in that case the last portion, being too strong, is likely to burn the foliage, and the first part may be too weak to do any good.

When to Spray.

Under each fruit mentioned in the following pages the proper time for spraying will be given, but it is desired to draw attention to and to emphasize one important fact, viz.: *treatment with fungicides is preventive, not remedial.* After a fungous disease has become established it cannot be cured, but it can be prevented, if preventable, if treatment is begun in time, hence it is important that the first application should be made early, generally before the leaves open, or, soon after.

It is too late to begin making applications of fungicides after the disease has made its appearance.

It should be remembered also that it is not always possible to wait for pleasant weather when spraying is to be done, but if good results are to be secured, the work cannot be delayed for any considerable length of time, hence it often becomes necessary to spray just before, or soon after a rain. In fact, nothing short of an actual rain storm should stop the work when the time comes when it should be done. Properly prepared mixtures will stick to the foliage, even through hard rain storms, provided they have half an hour in which to dry. Cloudy weather, or the appearance of rain, should not hinder the work.

Insecticides are not applied until the insects make their appearance, but it is not best to delay much longer than that time.

In order to answer numerous queries which have been made within the year, and to present certain facts as clearly as possible, each fruit will be considered by itself. This necessitates some repetition, but many of the questions asked show that considerable confusion exists regarding the various methods to be pursued in the treatment of different fruits. Especially is this true regarding the use of combination fungicides and insecticides. It will be necessary to go over some of the same ground covered in bulletin No. 9, Vol. IV, of this station, issued December, 1891, but the facts presented are for the most part new, and the methods of treatment have been modified to some extent,

SPRAYING THE PLUM.

The most troublesome insect affecting this fruit is the plum curculio. It has been repeatedly affirmed in bulletins published by this Station that the curculio can be controlled by spraying three or four times during the season with Paris green, and later experiments confirm these statements. A practical difficulty exists, however, in the fact that no matter how dilute the mixture, there is danger of injuring the foliage. This is due for the most part to the fact that the foliage of plum trees is seldom free from the disease commonly known as the shot-hole fungus, a name descriptive of a disease which causes the leaves to drop prematurely. This early dropping of the leaves injures the trees and prevents the proper development and ripening of the fruit. It becomes a necessity, therefore, to treat the foliage for the disease, whether the curculios are caught by jarring, or poisoned with Paris green, and particularly if the latter method is followed.

It follows, then, that the best mixture to use on plums is a combination, containing a fungicide and insecticide. This course was advised in the December bulletin of 1891, and further trial confirms the statements there made. Even those who hesitate to use Paris green admit the efficacy of the dilute Bordeaux mixture, and those who have fully tested both agree that the combination is entirely satisfactory. The formula for dilute Bordeaux mixture given on page 4 is used, and two ounces of Paris green or London purple added. This mixture is to be applied with a suitable force pump as soon as the blossoms have fallen, and repeated three or four times at intervals of one week. There does not seem to be any necessity for more than four applications, and three have been found to answer very well.

The treatment here outlined does not seem to prevent the plum rot to any extent. This disease is due to a specific fungus, but many growers, knowing the habit of the young brood of curculios of biting into the fruit late in the season, have attributed the rotting of it wholly to this cause, hence have taken no pains to destroy the dried plums which hang on the trees over winter. It is probable that these punctures made by the curculios late in the season afford a starting place for the plum-rot fungus, but no method can be given at present for preventing the rot, better than that often advised of picking off and burning the dried plums in the fall or winter. An early application of the Bordeaux mixture might also be advisable. One or two sprayings with two ounces of Paris green to fifty gallons of water might be safely made, after the time advised for the discontinuance of the Bordeaux mixture, provided the foliage is sufficiently healthy. This plan has not been tested, however, and should be cautiously tried. Jarring may become necessary in case the curculios are abundant late in the season.

The question has been repeatedly asked, will spraying with fungicides prevent the black knot? This question cannot be answered, as the matter has not been tested by experiment. The black knot can be controlled, however, by burning all badly diseased trees, and the affected branches of trees not seriously attacked. Diseased branches must be cut away and burned during the fall and winter. Possibly the spraying advised for the leaf disease will have some effect in checking the black knot, but it would not likely prevent it wholly. These directions apply to European varieties only. See "Spraying the Peach" for treatment of American varieties.

Cautions: Do not spray when the trees are in bloom, but do not delay making the first application more than a day or two after the blossoms have fallen. Do not continue much longer than advised, for the reason that the mixture, if applied too late, will stick to the fruit until after it is ripe. Fruit with a considerable quantity of the mixture adhering may be eaten without danger to the health, but such fruit is unmarketable, and washing is not practicable.

Spraying the Apple.

Our bulletin of December, 1891, shows conclusively that spraying to prevent the apple scab is beneficial and highly profitable. Some additional facts have since been noted which are deserving of special mention.

In the fall of 1891 a duplicate series of experiments was commenced with Baldwin, Bellflower, Newtown Pippin, Northern Spy, Smith's Cider and Seek-no-further to determine the relative keeping qualities of scabby apples and those free from scab. One hundred apples from each lot were selected, the scabby ones taken from the unsprayed, and those free from scab from the sprayed. All that showed indications of decay as well as all wormy specimens were rejected. Essentially the same results were obtained with the different lots. There were such variations as might be expected, but none contrary to the general rule, which was manifest in all cases, and may be stated as follows:

Apples free from scab kept better than scabby apples, but the greatest difference in keeping qualities was shown soon after the fruit was stored. This difference gradually diminished until the keeping qualities of both lots were nearly the same, but some of those free from scab were found to be sound for some time after all of the scabby apples had rotted.

The following example, taken from the results secured with the Newtown Pippin, illustrates the above statements: The apples were stored October 30, and were examined at frequent intervals. The total numbers found to be rotten at certain dates are given.

	Dec 4	Dec 25	Feb 19	Mar. 30	May 8	June 14
Free from scab, whole number rotten,	4,	13,	45,	66,	79,	100.
Scabby, whole number rotten,	12,	27,	78,	93,	100.	

In the first period, of a little more than a month, three times as many of the scabby as of those free from scab rotted, and with several other varieties the difference was nearly as great. The average number rotten in ten lots was 25 not scabby to 40 of the scabby. A more marked difference was shown in most varieties at the end of the first period of two weeks. If we take all the varieties except Newtown Pippin (none of which had rotted at the end of two weeks) it is found that on an average 5 not scabby had rotted to 13 of the scabby. If we compare those lots which kept until February 19, we find that 71 not scabby and 87 scabby had rotted

This shows clearly that the effect of the apple scab in causing rot is most marked at an early date, or soon after the apples are picked and stored. No doubt it often causes rot before the apples are gathered. The scab fungus, is, of course, only indirectly the cause of rot, but it undoubtedly is the source of great losses to orchardists. Probably fifty per cent. of the early decay of apples can be prevented by the use of proper remedies. Spraying to prevent the apple scab would no doubt pay, if for no other purpose than to improve the keeping qualities of the fruit.

The spring and early part of summer of 1892 was noted for the great amount of rainfall, and the work of spraying was seriously interfered with. The same orchard of Newtown Pippins was operated upon as in the season previous. Different mixtures were tested, but owing to the excessive rainfall some were washed off more than others, hence a fair comparison could not be made. The crop was not good in any part of the orchard, but one fact may be mentioned as worthy of notice: Three rows, running across the orchard, were left unsprayed, but none of the trees in these rows had any apples on worth picking, and but few of any kind. Had the entire orchard been left unsprayed the crop failure would have been the same on all parts, and the explanation that the frequent rains prevented pollenization of the blossoms would have been considered sufficient. There was sufficient bloom for a fair crop, but the above cause cannot be assigned, for the reason that on the sprayed trees there was a partial crop, differing of course according to the efficacy, or rather to the adhesive quality, of the mixtures. Four rows on the east side and four on the west side of the orchard were sprayed with the dilute Bordeaux mixture, and these rows were the only ones where anything like a satisfactory crop was found. That the application of this compound saved at least one-third of a crop is undeniable, but in what way was this result accomplished? When the young fruit is severely

attacked by apple scab it is often destroyed, and the action of the Bordeaux mixture was to prevent this to some extent, hence the partial crop where it was applied. At present this explanation seems tenable, and no other can be offered which will meet the case. Further confirmation is necessary before this belief can be established beyond a doubt, but it may be accepted as a good working hypothesis. It is not likely to lead to any serious consequences in practice, and may be the means of saving crops that would otherwise be lost. On another plot the treatment was with the same mixture, but the first application was omitted. The difference between this and the other two plots was considerably in favor of the early spraying.

It thus appears that the mixture used must be adhesive, and the first application must be made early in the season, before the buds open. There can be no question regarding the correctness of these conclusions, but the claim is not made that early spraying with any particular mixture will always insure a crop. Much depends upon the weather and other conditions. When the rainfall is abundant, and other conditions favorable for the early development of the scab fungus, the proper use of fungicides may be expected to have an effect similar to that above indicated, but in seasons when the scab finds unfavorable conditions for development the same treatment would show less marked results. The scab does more or less injury in all seasons, but it does not always get sufficiently started early enough to cause the destruction of the young fruit; but whatever the character of the season, early spraying is advisable.

In the December bulletin of 1891, one spraying was advised before blooming and three after; but it is now believed that it is better to make two applications before blooming and two after. The first is to be made just before the buds open, using either dilute or strong Bordeaux mixture, but preferably the latter. The second is to be made just before the blossoms open, using the same compound. For the third application, which should be made as soon as the blossoms have fallen, use the dilute Bordeaux mixture and to this add four ounces, or one-fourth of a pound, of Paris green or London purple to fifty gallons of the mixture. About this time the codlin moth lays its eggs in the blossom end or calyx of the apples. These eggs soon hatch and the young worms are killed by eating the poison, which explains its use. Another application of the same combination mixture should be made within ten days from the time of the third spraying. No further spraying during the season is advised. If desired, the ammoniacal solution of copper carbonate may be used some weeks later, but it is better to discontinue the use of the Bordeaux mixture at the time specified, as it sometimes causes a russet appearance on the fruit if applied too late. So far as observed, late applications have not been very beneficial, and four seem to be sufficient. This mat-

ter has not been fully settled by experiment, but no doubt much depends upon the compound used, the weather, the variety of fruit and the manner in which the work is done.

Cautions: Do not spray when the trees are in bloom, and do not delay the third application more than three or four days after the blossoms have fallen. If for any reason either London purple or Paris green is used alone, do not take more than one-fourth of a pound to fifty gallons of water. Do not use Bordeaux mixture later than specified on early apples nor upon white or yellow skinned sorts.

Spraying the Pear.

The pear is affected by a number of fungi and insects, some of which are the same as those found on the apple, and the treatment advised is nearly the same. The fruit is discolored by a fungus and the leaves drop prematurely from the same cause. The apple worm is found in the pear as well as in the apple; the plum curculio is more troublesome in pears than in apples; in fact, in many localities the necessity of keeping the curculio from injuring pears is quite as great as in the case of plums. The slug often does serious damage to pear leaves.

All of these enemies to the pear may be controlled by the use of combined mixtures, for insects and fungi. The first and second sprayings should be made with Bordeaux mixture, as advised for apples, although two applications before the time of blooming do not seem to be so necessary as in the case of apples, as the treatment seems to be more effective on the former than upon the latter.

The treatment after blooming may be the same as outlined for apples, but as the Bordeaux mixture, if used more than twice after blooming, causes a russet appearance on the fruit it is well to substitute the copper arsenic solution. Three or four sprayings should be made with this compound, commencing as soon as the blossoms have fallen, and continuing as long as the curculios appear to be working. The applications are to be made at intervals of about one week, and three are usually sufficient, but four or five will do no harm if the solution is properly prepared.

The scab on the pear causes early rotting, as with apples, and possibly in a still more marked degree. The cost of spraying will be repaid in the preservation of the fruit from rotting, if in no other particular.

Will spraying with fungicides prevent pear blight? This question has been asked many times at farmers' institutes, but no experiments have been made to determine what effect, if any, spraying has upon the blight. Probably spraying with fungicides can have no more than an indirect effect, by keeping the trees healthy and thus enabling them to

resist the blight to some extent. The matter is referred to here for the reason that the belief seems to be held by many that spraying with fungicides ought to prevent blight as well as other diseases.

Cautions: Do not use the Bordeaux mixture more than once after the time of blooming on early pears, nor more than twice after this period on any variety. Do not make the periods between the applications of the copper arsenic solution longer than ten days, and discontinue its use on early varieties at least a month before ripening.

Spraying the Quince.

Treat the same as recommended for the apple, or use Bordeaux mixture alone.

Spraying the Cherry.

The curculio, which causes cherries to be wormy, may be controlled by the use of Paris green. A fungous disease often causes many of the leaves to drop early in the season. Bordeaux mixture was tried for this the past season, but seemed to have an injurious effect upon the foliage, as more leaves dropped where it was used than where it was not.

Caution: Do not use London purple on cherry trees, and of Paris green not more than two ounces to fifty gallons of water, and make only two applications to early and three to late varieties.

Spraying the Peach.

The foliage of the peach is very easily injured, and will not bear the spraying requisite to keep the curculio in check. Early in the season, and sometimes later, a single application of Paris green, at the rate of two ounces to fifty gallons of water will do but little harm, but when the same mixture is applied several times in succession, as must be done for the curculio, the leaves usually drop quite badly in consequence. The liability to injure the foliage does not seem to be wholly avoided when Paris green and Bordeaux mixture are used in combination. These facts are stated in order that those who think of spraying peach trees may be on their guard. It is possible that the good effects in preventing the rot would be more than overbalanced by the slight harm done to the foliage, but this is still an open question. At present the best advice that can be given is to make not more than two applications, soon after blooming, using two pounds each of copper sulphate and quicklime and two ounces of Paris green to fifty gallons of water. This will do some good and not very much harm.

The same remarks and directions apply to the American varieties of plums, as the foliage of these is quite as tender as that of the peach.

Spraying Raspberries, Grapes and Potatoes.

Numerous queries have been received concerning the treatment for raspberry-cane scab, or anthracnose, grape rot and potato blight

The raspberry anthracnose was treated quite fully in our bulletin of October, 1891, and if any change is to be advised it is to use a weaker solution. Two pounds each of copper sulphate and quicklime would no doubt be sufficient, although this strength has not been fully tested.

For grapes the stronger Bordeaux mixture should be used for the first, second and third applications, which should be made just before the buds open, just before the time of blooming, and soon after the grapes are set. Two or three applications should be made thereafter with the ammoniacal copper carbonate solution, but do not use the Bordeaux mixture later than specified.

Potatoes should be treated with Bordeaux mixture and Paris green, at least five times during the season, commencing as soon as they are six inches high.

SUMMARY.

(1.) The profit to be derived from spraying orchards often exceeds $20.00 per acre, and for vineyards is much more. The fruit crop of the state would be enhanced in value by several million dollars annually if the practice were generally followed.

(2.) Combined fungicides and insecticides are recommended whenever applicable, because of a saving of time, a less liability of injuring foliage; greater efficiency in some cases, and as a precautionary measure in others.

(3.) Dilute Bordeaux mixture, copper-arsenic solution and ammoniacal solution of copper carbonate are the most useful for the treatment of the diseases herein mentioned, and the first has the widest range of usefulness of all.

(4.) Early spraying is the key to success in the use of fungicides.

(5.) For the plum curculio and shot-hole fungus use Bordeaux mixture and Paris green combined, making three or four applications.

It is not known that this treatment will prevent the black knot, but cutting away and burning the diseased branches will accomplish the result.

(6.) Scabby apples rot much earlier than those free from scab, and spraying with fungicides will save at least 50 per cent. of this loss.

(7.) Spraying with fungicides in the season of 1892 prevented much of the early dropping of apples, which is usually attributed to wet weather.

(8.) For apples, two applications of Bordeaux mixture before blooming are advised, and two of the same mixture after blooming, with Paris green added.

(9.) The same treatment is recommended for the pear as for the the apple, before blooming, but the copper-arsenic solution is advised after blooming.

(10.) The Bordeaux mixture, if used too late, causes a russet appearance on both pears and apples.

(11.) The quince may be treated the same as apples, or with Bordeaux mixture alone.

(12.) The treatment advised for the cherry consists in making two or three applications of Paris green, two ounces to fifty gallons of water.

(13.) Peach trees and American varieties of plums have very tender foliage, and must be treated with very weak mixtures, if at all.

(14.) Raspberries may be treated with Bordeaux mixture alone; grapes with the same until the fruit sets, after which use copper carbonate. Potatoes should be sprayed at least five times with Bordeaux mixture and Paris green.